Cisco ASR 1000 Series Aggregation Services Router High Availability: Delivering “Carrier-Class” Services to Midrange Router Systems

Today the aggregation edge of the network must be capable of managing massive video traffic growth and changes in the upstream and downstream mix resulting from Web 2.0 and collaborative business applications. Managing the ever-growing complexity of policy management and the integrity of the user experience is essential, yet emerging network requirements are occurring at a faster and faster rate. Service provider and enterprise networks are being transformed, and having the right solution at the network edge is increasingly important. This technological disruption has created new complexities and challenges for first-generation network edge designs. Emerging applications are accelerating a need for increasingly complex subscriber management functions. Because of the enormous number of parallel tasks that must be managed in real time, advances in memory management and performance are required. High Availability is now as essential at the edge as in the network core for both service providers and enterprise IT managers to maintain the integrity of the user experience. Neither environment can tolerate downtime or outages, thus motivating the demand for both in-box redundancy features and improvements in network-based availability.

Cisco® has created a new route processor to enable the delivery of a new price/performance class for high-end enterprise customer premises, enterprise WAN, and service provider edge routing solutions: the Cisco ASR 1000 Series Aggregation Services Routers. This new line is built to meet the specific needs of the aggregation edge and offers performance, scale, flexibility, security, and programmability while offering cost savings previously unachievable to benefit both service providers and enterprises. The Cisco ASR 1000 Series Router is designed as a carrier-class system for both service provider and enterprise environments with stringent high-availability requirements. This paper describes the carrier-class characteristics of these routers. It presents high-availability aspects from both hardware and software perspectives. Particularly highlighted are the innovations that the Cisco ASR 1000 Series Router offers from a high-availability perspective. The paper can help technical decision makers, network engineers, and even technically minded business development managers with a basic knowledge of the Cisco ASR 1000 Series Router architecture.

Cisco ASR 1000 Series Router High Availability Concepts

The hardware and software of the Cisco ASR 1000 Series Router are designed to meet the requirements of a carrier-class midrange routing system.

From a hardware perspective, the 12-shared port adapter (SPA)-slot Cisco ASR 1006 Router chassis allows for both redundant route processors (RPs) and embedded service processors (ESPs). The separation of the control- and data-plane functions onto the route processor and ESP, respectively, increases the resilience of the system against failures. A failure of the active route processor does not interrupt the data-forwarding path – the ESP continues to forward data packets

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transiting a Cisco ASR 1000 Series Router. Likewise, outages of the active ESP cause only minimal disruptions in the transit data traffic. The redundant ESP in a Cisco ASR 1006 Router operates in hot-standby mode, and thus maintains up-to-date forwarding state so it can immediately assume the forwarding functions if the active ESP fails. All systems in the Cisco ASR 1000 Series Router are also equipped with redundant power supplies (either dual AC or dual DC power supplies).

From a software perspective, the Cisco ASR 1000 Series Router takes full advantage of Cisco IOS® Software High Availability features. The Cisco ASR 1000 IOS XE Software offers basic High Availability features such as Configuration Synchronization, Warm Standby, and Warm Reboot. It also supports advanced High Availability features such as Nonstop Forwarding with Stateful Switchover (NSF/SSO), Multiprotocol Label Switching (MPLS) High Availability, Bidirectional Forwarding Detection (BFD), High Availability for the Cisco Session Border Controller (SBC-HA), and In Service Software Upgrade (ISSU). A major differentiator of the Cisco ASR 1000 Series Router is that it provides integrated services with outstanding performance in a midrange platform – and it offers such services *with High Availability.*

Improved resilience against outages is even supported on the non hardware -redundant Cisco ASR 1002 Router and Cisco ASR 1004 Router. Both systems allow for two independent Cisco IOS XE Software processes to run in their own protective memory spaces on the route processor. Each Cisco IOS XE Software process maintains its own system state information for control-plane, Layer 2, and Layer 3 protocols. This state is continuously mirrored from the active to the standby Cisco IOS XE Software process. Upon encountering a failure or forced switchover, the standby Cisco IOS XE Software process immediately starts the execution of control-plane functions and any resulting updates in its system state tables.

The remainder of this paper discusses the Cisco ASR 1000 Series Router carrier-class advantages, from both chassis-design and software perspectives.

Cisco ASR 1000 Series Router Carrier-Class Chassis Design

The three chassis types for the Cisco ASR 1000 Series Router offer varying degrees of High Availability support. The Cisco ASR 1006 Router chassis allows for redundant forwarding processors (ESPs) and redundant route processors (RP1s), and thus offers a higher degree of resilience against failures of these components. Both the Cisco ASR 1004 and 1002 model router chassis are designed for a single route processor and a single ESP, and they offer software High Availability by running two Cisco IOS XE Software processes in hot-standby mode.

Carrier-Class Aspects of Cisco ASR 1006 Router

In a fully redundant Cisco ASR 1006 Router (Figure 1), Cisco IOS XE Software runs on both route processors. One of the route processors and one of the ESPs are elected as the active route processor and the active ESP, respectively. With physically separate route-processor and ESP modules in a Cisco ASR 1006 Router, the design supports the localization of failures. A route-processor failure does not affect the forwarding capabilities of the state of either the active or the standby ESP. Similarly, if the active ESP fails, both route processors remain operational.

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Figure 1. Cisco ASR 1006 Series Router

The active route processor is particularly important for continuous operation of the Cisco ASR 1006 Router. After being elected as the active route processor in the system, it is responsible for:

- Sending and receiving network control-plane messages to other routers in the network and computing the control-plane state for various networking protocols: Protocols include, for example, Open Shortest Path First (OSPF), Border Gateway Protocol (BGP), Point-to-Point Protocol (PPP), Layer 2 Tunneling Protocol (L2TP), etc.
- Programming the forwarding state of the active ESP: When this step is completed, the Cisco ASR 1000 Router ESP can make forwarding decisions for data packets going through a Cisco ASR 1000 Series Router. The active ESP maintains the necessary forwarding databases such as the Cisco Express Forwarding tables locally.
- Managing control-plane and forwarding-plane state information in all the standby components (that is, both the standby ESP and the standby route processor): This task involves copying the computed forwarding state to the active ESP, and the current control-plane state to the standby route processor.

The internal Ethernet Out-of-Band Channel (EOBC) of the system is used to continuously exchange system state information between the different modules in the Cisco ASR 1006 Router chassis. Upon encountering a failure condition, a switchover event occurs and the standby route processor and ESP are immediately ready to assume the forwarding or control-plane functions for the failed component.

In a fully functional state, the active route processor monitors the system health using various internal mechanisms. Keepalives run between critical system components, and failure to receive them triggers a failover event. Alternatively, low-level interrupts may trigger failover events, for example, when a power-entry-module (PEM) failure occurs or when a route processor is manually removed from the system.

All failures can be logged using the onboard failure logging (OBFL) capabilities provided by Cisco ASR 1000 Series Routers. Flash memory on each of the modules (route processor, ESP, and SPA-interface-processor [SIP] carrier card) is provided to store any log files.

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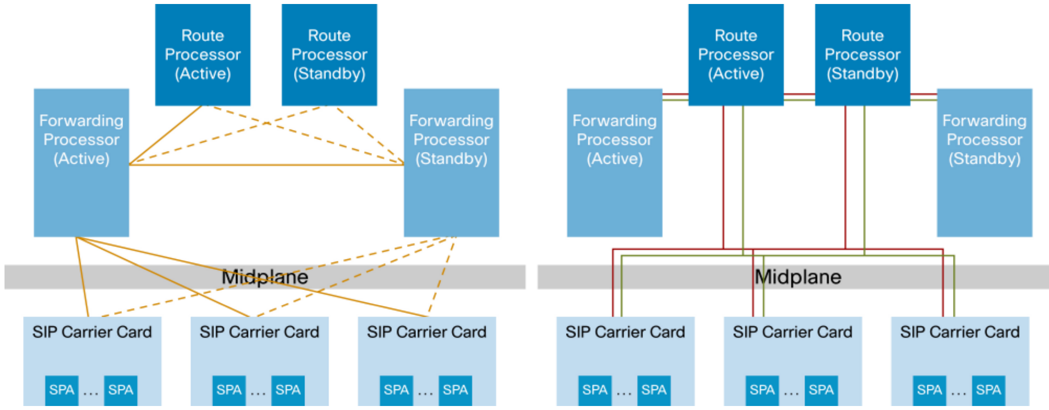
Figure 2 shows a high-level block diagram of the Cisco ASR 1006 Router, with its data-plane connectivity and control-plane connectivity.

Figure 2. Cisco ASR 1006 Block Diagram Showing Data-Plane (left) and Control-Plane (right) Links



Cisco ASR 1006 Router Failover Scenarios

One of the following scenarios occurs after a failure detection, depending on whether the active or standby route processor or the active or standby ESP fails.

- Failure of the active route processor: When a failure of the active route processor is detected, the internal circuitry of the Cisco ASR 1006 Router immediately initiates the state change of the standby route processor to “active.” Middleware software components inform both ESPs as well as all of the SIP cards (refer to Figure 5) about this state change. The middleware software components subsequently initiate the reconfiguration of all internal links. The data-plane link (enhanced Serdes Interface [ESI]) to the failed route processor is placed into loopback mode, the ESI links to the newly active route processor are turned on, and similar state changes are performed on the EOBC.

  When the internal circuitry switches over to the newly active route processor, its Cisco IOS XE Software process assumes the control-plane functions. The newly active route processor coordinates with both ESPs in the system to help ensure that all the state tables in the chassis are synchronized.

  In the meantime, the failed route processor undergoes a restart cycle. If the failed route processor restarts successfully, it assumes the role of the standby route processor in the chassis. In this role, the route processor receives the full state information from the newly active route processor. If the restart of the failed route processor is unsuccessful (for example, because of an unrecoverable hardware component outage), the Cisco ASR 1006 Router continues to run with a single route processor only.

  During this switchover period from the failed to the newly active route processor, packet forwarding continues on the active ESP. Transit packets are unaffected by the route-processor switchover event.

- Failure of the standby route processor: The process when the standby route processor fails is similar and even simpler than the failure case of the active route processor. When a failure of the standby route processor is detected, it goes into a restart cycle. If the failed standby route processor reboots successfully, the Cisco IOS XE Software control-plane state tables are resynchronized with the state tables maintained by the active route processor.

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Note that all active components in the system remain unaffected by the failure. Neither the ESI links nor the EOBC links need to be reconfigured. Both the active route processor and active ESP continue to execute the control-plane and forwarding-plane features, respectively. The redundant ESP also operates in standby mode and maintains its synchronization with the active ESP.

- Failure of the active ESP: A detection of an active ESP failure leads to a switchover event. The middleware components of the operating system on the active route processor register the failure. As in the case of an active route-processor failure, the ESI links are reconfigured to activate the links between the standby ESP and both the active and standby route processors. The ESI links between the SIP carrier cards and the standby ESP are also activated.

  The active route processor then sends a restart signal to the failed ESP. If the failed ESP reboots successfully, it resynchronizes its state with the active route processor. If the power cycling of the failed ESP is unsuccessful, the system continues to operate with a single ESP.

  Note that only the forwarding state tables are synchronized between the active route processor and both ESPs. Packet memory is not coordinated between the two ESPs, so failure of the active ESP causes a momentary loss of packets. Any packets that are in any of the ESP memory banks at the time of failure are lost.

- Failure of the standby ESP: Upon detection of a failure using, for example, the keepalive or interrupt mechanisms (depending on the failure type), the failed standby ESP enters a restart phase. If the reboot is successful, the active route processor populates the forwarding state information of the standby ESP. If the failure condition of the standby ESP is permanent, the system continues to operate with the single active ESP.

  Both the active and standby route processors continue to operate and to execute their functions in this failure case. The active route processor is even responsible for assisting the failed standby ESP to resume its standby role. Similarly, all data traffic continues to be forwarded on the active ESP. A failure of the standby ESP thus does not result in any packet losses.

High Availability Support on Cisco ASR 1002 and 1004 Model Routers

Although they offer different degrees of modularity, the Cisco ASR 1002 and 1004 model routers support a single route processor and a single ESP (Figure 3). Only the PEMs – either AC or DC – are redundant in both chassis, with full online-insertion-and-removal (OIR) capabilities.

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Figure 3. Cisco ASR 1002 and 1004 Model Routers

Nevertheless, the Cisco ASR 1000 Series Routers offer substantial software-based High Availability support on these chassis types – and at less expense than a fully hardware-redundant system. The innovative software architecture of the Cisco ASR 1000 Series Routers facilitates this support: Cisco IOS XE Software on the routers runs as a process on a Linux-based kernel. This architecture allows for two independent Cisco IOS XE Software processes to run side by side on the same kernel. Such a configuration is supported on both the Cisco 1002 and 1004 model routers. The memory requirement for such an arrangement is 4 GB of DRAM. Each of the two independent Cisco IOS XE Software processes runs in its own protected memory space.

Figure 4 illustrates the Cisco IOS XE Software High Availability infrastructure in this case. Note that two Cisco IOS XE Software processes running on the same active route processor are depicted. An interprocess communication protocol (IPC) is established between the active and standby Cisco IOS XE Software processes running on the same route processor (instead of the active and standby Cisco IOS XE Software running on disparate route-processor modules in a Cisco ASR 1006 Router). Communication over this reliable IPC is identical to the case with redundant route-processor modules: the active Cisco IOS XE Software maintains the master state tables for various Layer 2 and Layer 3 protocols and features. The standby Cisco IOS XE Software maintains its own copies of the system state tables. The IPC between the High Availability subsystems on the active and standby Cisco IOS XE Software helps ensure that the system state is kept synchronized between the independent copies of the state tables.

The standby Cisco IOS XE Software detects a failure of the active Cisco IOS XE Software with the keepalive mechanism. The standby Cisco IOS XE Software then assumes the control-plane processing responsibilities. Because in such a configuration the standby Cisco IOS XE Software has up-to-date state tables, such a switchover event does not disrupt control-plane traffic. The newly active Cisco IOS XE Software process handles control-plane updates. The local tables are updated when necessary. Recall that data-plane traffic not destined for the route processor is unaffected by such a failure event. The ESP in the chassis continues to forward data-plane transit traffic according to its local forwarding state information.

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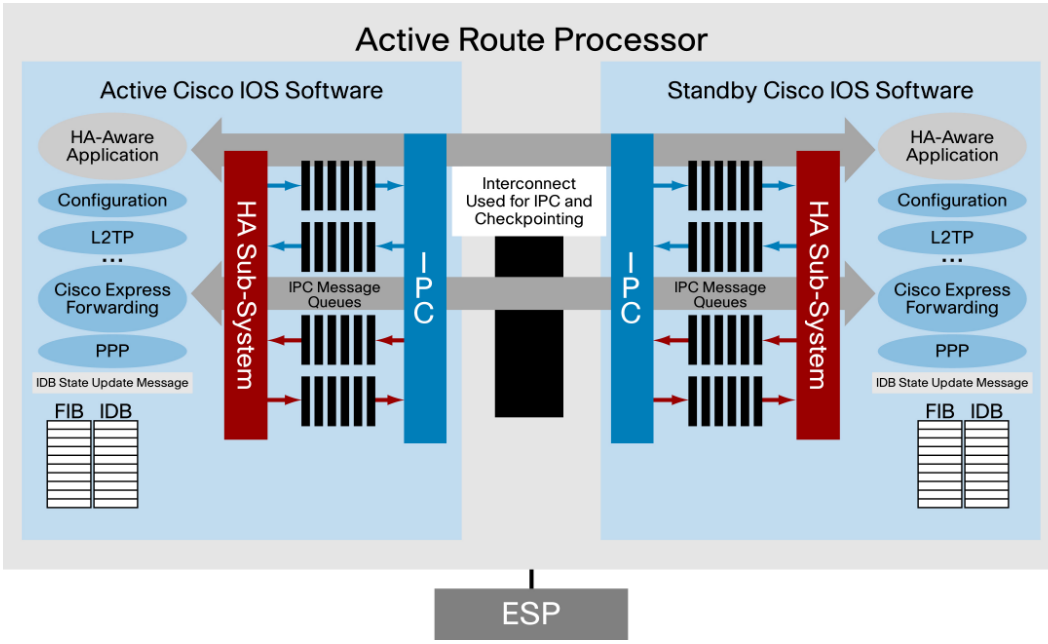
Figure 4. High Availability Architecture on Cisco ASR 1002 and 1004 Model Router Systems



Cisco IOS XE Software High Availability capabilities on the Cisco ASR 1002 and 1004 model routers are particularly valuable for ISSU. The active and standby Cisco IOS XE Software do not need to be the same version; they can be ISSU-compatible. Cisco ASR 1000 Series Router software High Availability capabilities thus help ensure that Cisco IOS XE Software upgrades are transparent.

Cisco ASR 1000 Series Router Carrier-Class Software Infrastructure

The software design is another major differentiator of the Cisco ASR 1000 Series Router compared to existing midrange systems. The Cisco ASR 1000 Series Router offers the feature richness of Cisco IOS XE Software, as well as software modularity for important system processes. The software architecture takes full advantage of a Linux-based kernel that is supported by various middleware software components. A combination of a Linux kernel and middleware processes drives each of the hardware modules in the Cisco ASR 1000 Series Routers. Additional modular software components run on top of this infrastructure. A Cisco IOS XE Software image runs on both route-processor modules, and provides the Cisco IOS Software feature richness for the Cisco ASR 1000 Series Router. SPA interface drivers run on the SIP carrier cards. The Cisco QuantumFlow Processor (QFP) forwarding software is a process that runs on the ESP forwarding processors.

Figure 5 illustrates the main components of the Cisco ASR 1000 Series Router modular software architecture. The individual modules follow:

- Linux kernel: The kernel is responsible for all low-level operating system functions, such as process scheduling, memory access, interrupt handling, etc. It also manages the connectivity between the modular components in a Cisco ASR 1000 Series Router. The kernel offers process preemption capabilities, and thus allows for prioritizing of processes under its control.
- Cisco IOS XE Software middleware: The Cisco ASR 1000 Series Router middleware components assist the Linux kernel in managing the chassis and facilitating the modular nature of the system architecture. First, chassis-management information is exchanged between the route processors and all other hardware modules in the chassis, allowing the

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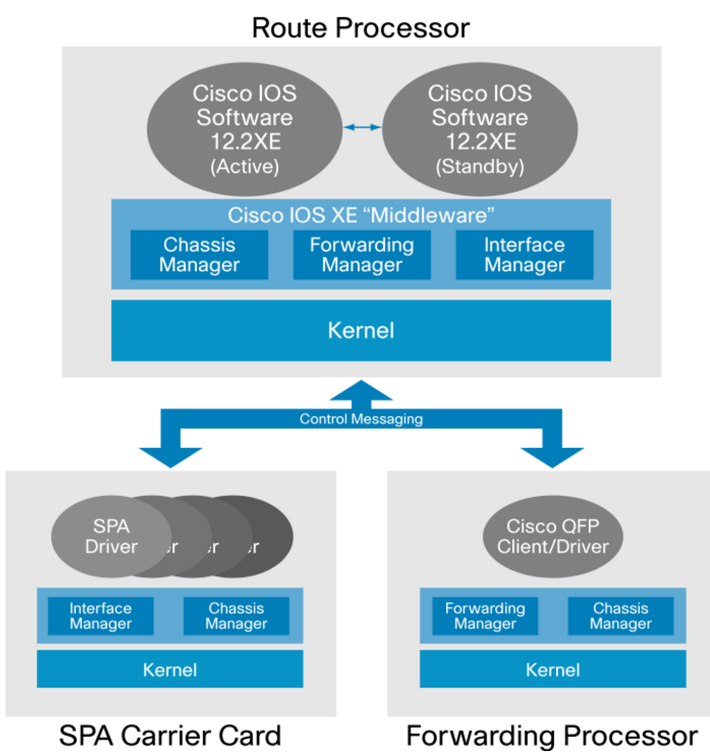
route processor to have an up-to-date status of the type of module that is present in the system. The chassis-management processes are also important for module restart, the monitoring of environmental conditions, or the management and initialization of the interconnection infrastructure through the midplane. Second, interface-management processes communicate with each other on the route processor and each of the SIPs in the system. Interface-status information, tunnel configurations, or statistics are thus communicated to the route processor. Third, the forwarding-management processes communicate with each other between the route processors and the ESP. State information and statistics are reported to the route processor in this way. Alternatively, the forwarding information is pushed from the route processor to the ESPs.

- Cisco IOS XE Software: Cisco IOS Software on the Cisco ASR 1000 Series Router offers the network features and functions that define the routing system as a router. It is responsible for the execution of routing protocols, in addition to managing Layer 2 protocols, tunnel or various other virtual interfaces, broadband sessions, Simple Network Management Protocol (SNMP), and other management features as well as the command line to configure the routing system.
- SPA interface drivers: Each SPA interface module is governed by its own software driver, which is responsible for the proper operation of the SPA and facilitation of its communication with the SIP carrier card. The SPA drivers are also responsible for physical layer communication functions.
- Cisco QuantumFlow Processor forwarding software: This software implements the forwarding plane that drives the Cisco ASR 1000 Series Router high-performance forwarding capability on the Cisco QuantumFlow Processor. The QFP software also allocates and manages the various onboard resources on the ESP. Cisco IOS XE Software running on the route processor communicates with the QFP software modules through the IPC.

Figure 5. Cisco ASR 1000 Series Software Infrastructure



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All of the Cisco IOS XE Software modules run in their own protective memory spaces. This feature is particularly important from a carrier-class perspective, because it facilitates fault containment. Any software outages of an individual software module are localized to that particular module. All other software processes continue to operate. For example, for each SPA interface card, a separate driver process is executed on the SPA carrier card, even if multiple SPAs of the same type are present. Because each SPA driver runs in its own protective memory, failure or upgrade of an individual driver is thus localized to the affected SPA only.

The modular software architecture in the Cisco ASR 1000 Series Router also provides the basis for ISSU or process restartability. On a fully hardware-redundant Cisco ASR 1006 Router, all software processes can be upgraded in service or restarted individually. Even on the Cisco ASR 1002 and 1004 model routers, ISSU is supported for the Cisco IOS XE Software or the middleware software modules running on the route processor. Additional details about ISSU are provided in the next section.

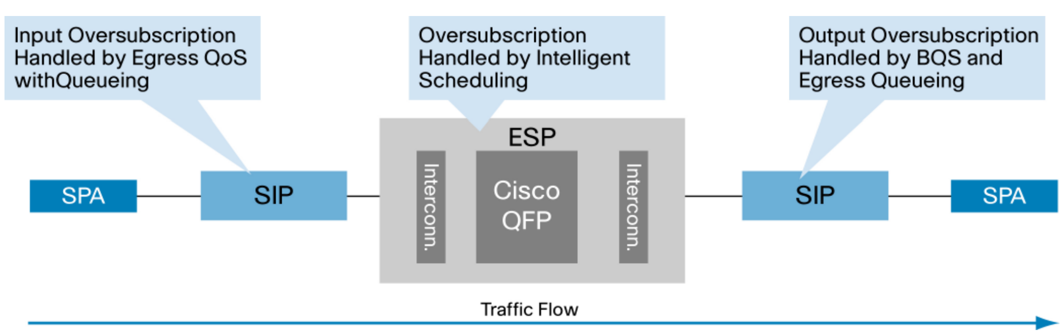
Service Availability with Cisco ASR 1000 Series Routers

For many service provider and enterprise applications, service availability is achieved by using both hardware and software High Availability features and quality-of-service (QoS) mechanisms. The Cisco ASR 1000 Series Router architecture provides the necessary control mechanisms throughout the entire path of a packet through the system, allowing for prioritization of traffic in line with the underlying services.

For example, the SIP card allows for classification and scheduling of ingress packets into high- and low-priority queues. Traffic belonging to critical services can thus already be treated with higher priority on its way to the forwarding engine. Similarly, within the ESP, the Cisco ASR 1000 Series Router provides extensive QoS mechanisms to support service availability. Depending on the underlying service, traffic can be scheduled into absolute priority queues (low-latency queues), into queues that are given relative priorities (weighted fair queues), or into a best-effort queue. The scheduler in the Cisco ASR 1000 Series Router supports multiple scheduling hierarchies and allows for minimum bandwidth, maximum bandwidth, and excess bandwidth scheduling per class. This setup enables more complicated service mechanisms, where even bundled services destined to a particular subscriber can be adequately supported by a QoS mechanism. Upon leaving a Cisco ASR 1000 Series Router, egress queues again absorb short-term traffic bursts and thus complete the QoS support through the system.

Figure 6 provides a high-level summary of the Cisco ASR 1000 Series QoS control points.

Figure 6. Cisco ASR 1000 Series Router QoS Mechanisms for Service Availability



Further details about the Cisco ASR 1000 Series Router QoS mechanisms are available at http://www.cisco.com/en/US/prod/collateral/routers/ps9343/solution_overview_c22-

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449961_ps9343_Product_Solution_Overview.html [2]. For additional details about the Cisco QFP support for services, please visit http://www.cisco.com/en/US/prod/collateral/routers/ps9343/solution_overview_c22-448936.html [1].

State-of-the-Art High Availability on Cisco ASR 1000 Series Routers

In general, individual High Availability features in the Cisco IOS XE Software are categorized into one of three classes in Cisco IOS XE Software: network-level resiliency, system-level resiliency, and embedded management features.

- Network-level resiliency features take advantage of the distributed nature of the IP network and its control plane to react in case of an outage. The operational routers in the network cooperate to direct traffic away from failed nodes or links, and assist in rebuilding the control-plane state of the failed routing system when it becomes active again. Examples of such features include IP Routing protocols with Fast Convergence support, BFD, or NSF awareness.
- System-level resiliency features localize the reaction to a failure within a routing system. Features such as NSF/SSO, stateful Layer 2 or Layer 3 protocol support, Warm Reload, or Warm Upgrade rely on the in-box redundancy of a router to maintain separate and independent state information. When an outage occurs, the mirrored state tables make forwarding decisions, and this process is transparent to any neighboring routers in the network.
- Embedded management features support the overall high-availability concept by providing mechanisms to manage outages. Early warning signals can be triggered, for example, using the Cisco IOS Embedded Event Manager (EEM) function, where an operator can define thresholds and notification events are generated when the thresholds are passed. Another example of a feature in this category is Configuration Rollback, which allows an operator to return to a previous version of a router configuration.

Figure 7 illustrates Cisco High Availability feature categories.

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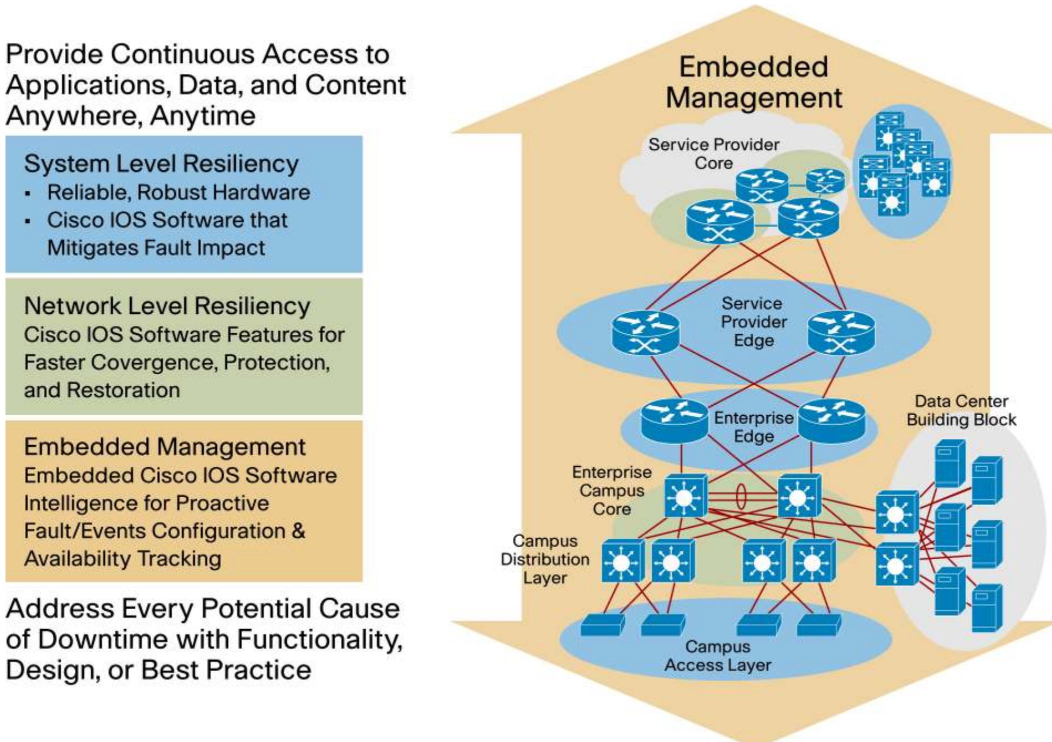
Figure 7. Cisco IOS XE Software High Availability Feature Categories



The following software features supported on the Cisco ASR 1000 Series Router are particularly innovative in the midrange routing space:

- NSF/SSO
- MPLS NSF/SSO
- BFD
- SBC High Availability
- ISSU

Nonstop Forwarding with Stateful Switchover in the Cisco ASR 1006 Router

NSF/SSO relies on redundant route processors and ESPs, and in particular independent routing tables (Routing Information Base [RIB]) and Cisco Express Forwarding tables (Forwarding Information Base [FIB]). The independence of the forwarding state in the Cisco ASR 1000 Series Router ESP modules helps ensure that traffic forwarding is nonstop, even in the face of route-processor or ESP outages (in the case of a redundant Cisco ASR 1006 Router). One aspect of NSF/SSO is thus to help ensure that forwarding state is maintained between redundant components in the Cisco ASR 1006 Router. SSO is responsible for fully initializing the standby route processor and ESP in preparation for a switchover. The startup and running configurations are copied from the active to the standby route processor. SSO also maintains application or Layer 2 session state for all stateful applications or protocols.

Moreover, NSF/SSO also mitigates potential network instability conditions that could result in its absence. Upon a switchover to a redundant route processor after an outage of the active route processor, neighbor adjacencies may be torn down and need to be reestablished. A neighboring router can thus detect a switchover, and it could declare a complete system outage to the rest of

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the network using standard routing protocol mechanisms. NSF/SSO prevents such a condition by allowing for the negotiation of Graceful Restart capabilities between neighboring routers. Upon establishment of the neighbor adjacency, a Graceful Restart capability is communicated to the neighboring routers. When the neighbor relationship to a Graceful Restart-capable neighboring router is lost (because of a route-processor failover, for example), the routers surrounding the faulty router no longer propagate a loss of adjacency to the remaining routing systems in the network. Instead they help reestablish both the neighbor adjacencies and the latest routing state, and thus contribute to overall network stability. For further details about NSF/SSO, please see the deployment guide at: http://www.cisco.com/en/US/technologies/tk869/tk769/technologies_white_paper0900aecd801dc5e2.html [3].

MPLS NSF/SSO in the Cisco ASR 1006 Router

Support for MPLS NSF/SSO extends the NSF/SSO feature to an MPLS environment. In particular, it helps ensure that label-based forwarding information is synchronized in the Cisco ASR 1000 Series Router ESPs by synchronizing the Label Forwarding Information Base (LFIB). The LFIB is also synchronized between the active and standby route processor in this case. Furthermore, the MPLS NSF/SSO feature helps ensure that label-binding information in the Label Information Base (LIB) is synchronized between the active and standby route processors in a Cisco ASR 1006 Router.

Similar to the case for routing protocols described previously, a route-processor failure could lead to a loss of adjacency of the Label Distribution Protocol (LDP) sessions that are used to exchange label bindings between peering routers. Although a failover event of an active route processor to a standby route processor on a Cisco ASR 1006 Router may lead to the loss of LDP adjacency, the LDP Graceful Restart capabilities again help ensure that the actual label bindings are not lost in the failing system. The LDP peers again help the failing router reestablish the LDP adjacency and validate the LDP label bindings. As described previously, the LDP neighbors have to be LDP Graceful Restart-aware to perform these operations.

Bidirectional Forwarding Detection

BFD is a fast hello protocol that is increasingly used to support faster convergence or failure detection for a variety of media types, encapsulations, topologies, or routing protocols. The Cisco ASR 1000 Series Routers support the asynchronous BFD mode, thereby enabling the establishment of BFD sessions with neighboring routers and the exchange of BFD control packets between the BFD neighbors. Upper-layer routing protocols can use these keepalive mechanisms in addition to or as a replacement for their own hello mechanisms. BFD can send fast failure-detection event notices to routing protocols, and thus allows much faster reconvergence times.

BFD is implemented in the Cisco ASR 1000 Series Routers on the route processor, and is thus fully stateful. Both active and standby route processors maintain the BFD state information.

SBC High Availability

One of the key differentiators of the Cisco ASR 1000 Series Router is its support for SBC functions. In particular, the Cisco ASR 1000 Series Router can function as a distributed border element (DBE) in an SBC environment. It receives control messages from the session border element (SBE) using the H.248 control protocol, and thus can open and close media pinholes and provide the data plane for session border-controlled traffic.

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As with the High Availability features discussed previously, the Cisco ASR 1006 Series Router can synchronize SBC session state between the active and standby route processors or ESPs. A failure of the active route processor again results in a switchover to the standby route processor. Any H.248 control message processing can immediately be resumed on the standby route processor. Similarly, the standby ESP also maintains a copy of the DBE forwarding state tables, and is thus immediately ready to take over the forwarding function for SBC-controlled traffic if the active ESP fails.

Further details about the SBC High Availability capabilities of the Cisco ASR 1000 Series Router are available at:
http://www.cisco.com/en/US/prod/collateral/routers/ps9343/solution_overview_c22-448240.html [4]

In Service Software Upgrade

ISSU provides the capability to upgrade the Cisco ASR 1000 Series Router operating system software while the router is still passing traffic (in service). This feature is particularly valuable to service provider and enterprise customers because it reduces system downtime and thus contributes to the overall availability of the network and services generated thereon. Without ISSU, any scenario requiring a software upgrade or patch needs a router reload, which in most cases lead to disruptions in customer connectivity.

The ISSU function in Cisco IOS XE Software extends the NSF/SSO capabilities with version control. ISSU verifies feature and capability consistency between two disparate Cisco IOS XE Software releases. Sanity checks are performed to help ensure that an existing configuration operates consistently in the new software version. ISSU uses software compatibility matrices between different Cisco IOS XE Software releases to perform these checks, reducing troubleshooting and downtime incurred in case of possible failed upgrades. If the new Cisco IOS XE Software release is ISSU-compatible with the existing software version, NSF/SSO mechanisms are used to switch over from the active to the standby ESP on a Cisco ASR 1000 Series Router.

This ISSU description also applies for downgrades, where a previous release of Cisco IOS XE Software is being installed to replace a later version.

ISSU is not restricted to the Cisco ASR 1006 Router; the Cisco ASR 1002 and 1004 model routers also have ISSU capabilities for the Cisco IOS XE Software or route-processor middleware software modules.

Applications

Figure 8 illustrates a sample deployment of a large number of Cisco ASR 1006 Routers to support a next-generation triple-play (data, voice, and video) broadband network offering voice, voice with video, video on demand, broadcast TV, and high-speed Internet access services. The Cisco ASR 1006 Routers in this network provide the edge functions. Up to 16,000 subscribers are terminated on a single Cisco ASR 1006 Router using per-customer VLANs. For traffic arriving from the subscribers, the Cisco ASR 1000 Series Router is the first IP hop in the network. Traffic for the different services is routed toward the core to reach its destination. Similarly, for traffic destined for a subscriber, the Cisco ASR 1006 is the last IP hop on the end-to-end path.

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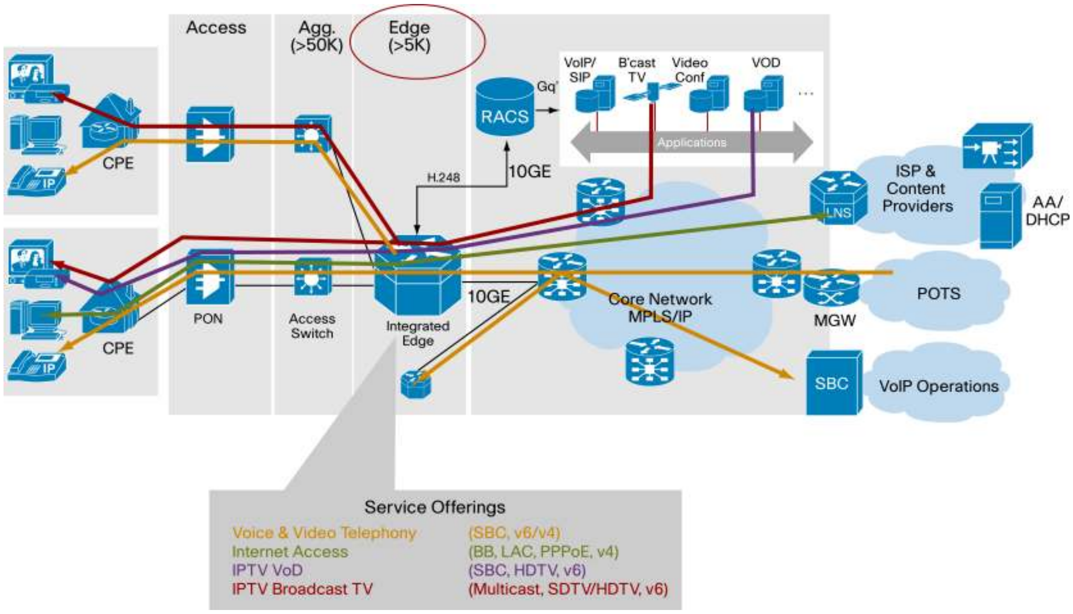
Figure 8. Carrier-Class Next-Generation Broadband Network Based on Cisco ASR 1006 Router



The following High Availability features are configured on each Cisco ASR 1006 Router:

- NSF/SSO: Each of the Cisco ASR 1006 Routers is equipped with redundant route-processor and ESP modules. NSF/SSO functions help ensure that Cisco IOS XE Software configurations and other protocol state information are synchronized at all times. This scenario maintains the standby route processor and ESP in a permanent state of readiness to take over forwarding functions if the active route processor or ESP fails.
- Redundant 10 Gigabit Ethernet uplinks: Each Cisco ASR 1000 Series Router is configured with redundant 10 Gigabit Ethernet links toward the IP core network. Routing functions help ensure that a failure of an uplink does not isolate the router. In such a case, the OSPF routing protocol would redirect traffic toward the core on the secondary uplink.
- SBC High Availability: Voice and voice-with-video services are implemented in this next-generation network by the SBC function. The Cisco ASR 1006 Router maintains a synchronized session and forwarding state in the route-processor and ESP modules, and thus guarantees that voice and voice-with-video services are resilient to component outages.
- BFD: Bidirectional Forwarding Detection is used in this network deployment to support Fast Convergence of routing. The BGP and OSPF routing protocols are linked to BFD, and can thus benefit from the fast failure-detection capability offered by BFD.

The combination of these state-of-the-art High Availability features on the Cisco ASR 1006 Router facilitates revenue-generating, triple-play services in this network.

Conclusion

The Cisco ASR 1000 Series Router is a small, powerful router that can greatly reduce the need for power, space, sparing, and maintenance. It was built to address the complexities of today's combination of voice, video, and data services while offering providers the flexibility to meet the challenges of service delivery for decades to come. It offers a carrier-class software and hardware

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design, providing substantially increased resilience against component outages and thus facilitating higher overall system and network availability.

The Cisco ASR 1006 Router is fully hardware-redundant. The separation of the control and forwarding planes on the route processor and ESP provide for localization of failures. A route-processor outage does not affect the traffic forwarding on the ESP at all. Similarly, the standby ESP can take over upon failure of the active ESP without affecting the operation of the active route processor. Even the non-hardware-redundant Cisco ASR 1002 and 1004 model routers provide for software High Availability for lower-cost implementations.

The Cisco ASR 1000 Series Router Linux-based software architecture allows for two Cisco IOS XE Software processes to run in hot-standby mode on a single route processor. The hardware and software carrier-class characteristics of the Cisco ASR 1000 Series Router are used to advantage by a breadth of high-availability features supported in Cisco IOS XE Software. Features such as NSF/SSO, MPLS NSF/SSO, and even SBC High Availability and ISSU make the Cisco ASR 1000 Series Routers ideal for service provider and enterprise networks with stringent availability requirements.

For More Information

For more information about the Cisco ASR 1000 Series Routers and related technologies, please visit:

[1] The Cisco QuantumFlow Processor: Cisco's Next Generation Network Processor, http://www.cisco.com/en/US/prod/collateral/routers/ps9343/solution_overview_c22-448936.html

[2] ASR 1000 Series: QoS Architectures and Solutions, http://www.cisco.com/en/US/prod/collateral/routers/ps9343/solution_overview_c22-449961_ps9343_Product_Solution_Overview.html

[3] Cisco Nonstop Forwarding with Stateful Switchover Deployment Guide, http://www.cisco.com/en/US/technologies/tk869/tk769/technologies_white_paper0900aecd801dc5e2.html

[4] ASR 1000 Series: Session Border Controller, http://www.cisco.com/en/US/prod/collateral/routers/ps9343/solution_overview_c22-448240.html

Americas Headquarters
Cisco Systems, Inc.
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Asia Pacific Headquarters
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Printed in USA

C22-450809-00 03/08

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